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# Climate Change and Sustainability in Spanish Classrooms: State of the Art and Didactic Proposal

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**Abstract:** Climate change has become a global challenge that must be faced in a cross-cutting manner from multiple fields and involving all citizens. The educational system, as a space that guarantees the training of students and the integral development of the person at the social, intellectual and ethical levels, should be oriented towards increasing the environmental awareness of society, promoting practices and habits that respect the preservation of ecosystems and, in short, education for sustainability. The 2023–2024 academic year is the first in which the curricular content developed from the Organic Law 3/2020, of December 29, which modifies the Organic Law 2/2006, of May 3, on Education, popularly known as LOMLOE, will be fully implemented. This paper designs a learning situation on sustainability and climate change that can be implemented in the Spanish and European contexts, responding to Rosenshine's principles of instruction, a circumstance that gives it enormous flexibility and makes it an interesting resource focused on helping geography teachers to face current challenges from an innovative, scientific, and inclusive perspective.

**Keywords:** teaching; climate change; sustainability; education; Rosenshine



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## 1. Introduction

It is likely that, apart from the great wars of history, humanity has never faced a threat as pressing as climate change. This phenomenon, whose existence and causes (linked to anthropogenic activity) have been rigorously proven by practically the entire scientific community (Lynas et al. 2021), represents a major problem that has led, in recent decades, to the implementation of numerous regulatory instruments and strategies aimed at promoting the acquisition of environmentally sustainable attitudes and practices (MITECO 2022). Thus, for some time now, public institutions have been trying to raise awareness of the importance of moving towards positions that respect ecosystems and their limits and safeguard natural resources through the promotion of socioeconomic development that does not compromise the right of future generations to meet their own needs and enjoy the Earth responsibly (CMMA 1987).

One of the most noteworthy initiatives in this regard in recent years has been the approval of the Sustainable Development Goals—hereinafter referred to as SDGs—in 2015, which have made it possible to deepen the challenges included in the Millennium Development Goals, promoted in 2000, to embrace a more ambitious and holistic perspective of human development. Within the catalog of seventeen approved SDGs, there are several that are directly linked to the preservation of the environment and the fight against climate change, such as 13—climate action, 15—life on land, or 7—affordable and clean energy (United Nations 2022). At a Spanish scale, in this century both the Central State Administration and the Autonomous Communities have promoted, based on European and international guidelines, the elaboration of numerous strategies and documents of a legislative nature that together make up what could be catalogued as the national regulatory corpus of climate action. Within this compendium, it is worth highlighting, as an example,

Law 7/2021, of May 20, on climate change and energy transition (BOE No. 121, of May 21 2021) or the National Plan for Adaptation to Climate Change 2021–2030 (MITECO 2020).

However, the public is highly skeptical about the effectiveness of these measures. Recent opinion polls show that 92% of the Spanish population agrees that action against climate change and environmental degradation is slow, so that the majority do not believe that Spain will achieve a substantial reduction in its carbon dioxide emissions before 2030 (European Investment Bank 2022). In addition, various interest groups and experts have denounced the measures promoted by the authorities as insufficient to achieve the commitments acquired in climate matters (De Miguel 2020).

The fact is that, according to the Climate Change Performance Index, Spain is in the twenty-third position worldwide, having risen eleven places in this ranking in the last year (Germanwatch 2022). In turn, according to the Environmental Performance Index, the country is the twenty-seventh for the best performance in achieving sustainability in general; although, in terms of climate policies, the Spanish situation can be clearly improved, being placed in a deficient 83rd position at international level (Wolf et al. 2022).

On the other hand, several authors have proven the importance of raising awareness and sensitizing citizens in order to involve them in the fight against climate change through the education system (González-Gaudiano 2007; Anderson 2013; Sánchez-Almodóvar et al. 2022). Thus, most research agrees that educational level is "the strongest predictor of climate change awareness" (Ming-Lee et al. 2015), a circumstance that has encouraged the inclusion of the educational sphere in the main climate action policy documents in most European states.

At the same time, it is worth noting the importance given to education by the Intergovernmental Panel on Climate Change—IPCC—which, in the six assessment reports it has produced since 1990, has included specific proposals to be applied in the field of education (Sánchez-Almodóvar et al. 2022), including the need to create environmental awareness campaigns, encourage the participation of all sectors of the population, and promote collaboration between scientists, policymakers, and all interested parties. Likewise, the Incheon Declaration and the Framework for Action for the implementation of Sustainable Development Goal 4 shows the interest and usefulness of a commitment to quality education that prepares young people and adults for a world in constant change and with enormous challenges to be faced from the perspective of resilience and balance between meeting social needs and caring for the environment (UNESCO 2016).

The European Union, for its part, has on several occasions endorsed international trends in education for sustainability, stating that member states must intensify efforts to ensure that education becomes a space that fully promotes ecological transition and sustainable development, pointing out the importance of implementing interdisciplinary and cross-cutting activities that contribute, directly or indirectly, to encouraging sustainable lifestyles, taking care of nature, etc. (OJEU No. 243 of June 27 2022).

In Spain, Law 7/2021, of May 20, on climate change and energy transition, dedicates its Title VIII to "Education, research and innovation in the fight against climate change and energy transition," indicating that the national education system must promote the involvement of society in the responses designed to combat this phenomenon, expanding knowledge about it and preparing citizens for the development of a resilient and responsible technical and professional activity (BOE No. 121, of May 21 2021). Similarly, Article 35.2 establishes the need to review the treatment of climate change and sustainability in the basic curriculum of the teachings of the educational system in a cross-cutting manner, as well as the obligation to adequately train teachers in these subjects.

The autonomous communities, with broad competences in education (Aragón-Reyes 2013), have also assumed, in their respective legislation on the climate challenge, the relevance of education as an essential instrument to build a culture of sustainability and resilience; examples of this are the climate change laws of the Valencian Community (DOCV No. 9486, of December 9 2022), Andalusia (BOJA No. 199, of October 15 2018), and Catalonia (DOGC No. 7426, of August 3 2017).

However, the notable lack of consensus and educational instability suffered by Spain, which in its democratic period has approved or had in force a total of nine educational laws—LGE, LOECE, LODE, LOGSE, LOPEG, LOCE, LOE, LOMCE, and LOMLOE—is an obstacle to the achievement of the goals set given the short period of effective implementation of the different regulations, which are continually subject to revision and political controversy (Novella and Cloquell 2021). Nevertheless, Spain's prolific legislative activity in the field of education is a resource of undoubted interest that allows us to analyze in detail how the treatment of environmental issues has changed over the last four decades at the regulatory level, a circumstance that has encouraged research activity in this regard (Caballero et al. 2021; Morote and Olcina 2021).

The latest Spanish education law, popularly known as LOMLOE (Organic Law 3/2020, of December 29, amending Organic Law 2/2006, of May 3, on Education), states in its preamble that the education system cannot ignore the challenges posed by climate change, so that schools must become places of "custody and care" of the environment, promoting a culture "of environmental sustainability, social cooperation, developing programs for sustainable lifestyles, and encouraging recycling and contact with green spaces" (BOE No. 340, of December 30 2020). The autonomous communities, for their part, have assumed this commitment in the process of approving the new curricula for Compulsory Secondary Education and Baccalaureate, which insist on the need for students to be aware of the planet's environmental problems, know the causes and consequences of climate change, and acquire sustainable habits in their academic and personal lives (Ministry of Education and Vocational Training 2022a).

What has been mentioned so far justifies the multiple works that have been carried out in recent years on the teaching of climate change and sustainability in the educational system. From different disciplines, the international scientific community has generated abundant and innovative teaching material on the issue, as well as a profound reflection on the objectives to be achieved (Maxwell and Blashki 2016; Siperstein et al. 2017; Murga-Menoyo and Bautista-Cerro 2019)

However, the above mentioned regulatory instability to which teachers are subjected, the continuous remodeling of curricula, the delay of some regional governments in decreeing the organization of subjects—in the Canary Islands, for example, the 2022–2023 academic year has been developed following a draft curriculum—the ambivalence exhibited by the LOMLOE on issues such as sustainability, and the lack of training in geographic content that teachers sometimes show in social sciences, lead teachers to a situation of uncertainty in the face of new content that, in addition, must be addressed in a cross-cutting manner, according to the legislation.

Some or all of the proposed activities can be worked on at different educational levels and from other related subjects, such as biology and geology, not only geography. Consequently, the main objective is to provide teachers with tools, not specific contents—a "how" rather than a "what"—so that this perspective of environmental education can be assumed in multiple educational contexts, from the earliest ages to the university, adapting the level of demand and difficulty to the intellectual maturity of the students.

The principles designed by Barak Rosenshine constitute one of the most effective methods for teaching, proposing a series of flexible steps from which to structure the contents and activities in the classroom so that the student progressively acquires the desired knowledge, consults appropriate sources of information, is able to make critical judgments, and, finally, has the basic skills necessary for the resolution of an independent practice (Rosenshine 2010).

In this context, the main objective of this paper is to present a learning situation that can be totally or partially applied in different European educational contexts, although the 2nd year of baccalaureate is taken as a reference based on the current regulations in force in the autonomous community of the Canary Islands on climate change and sustainability. It is intended, therefore, to provide teachers with specific and updated resources and

activities to work on the issue in the classroom following a systematic, rigorous, and problem-solving-oriented methodology.

In the following section, with the purpose of contextualizing the issue at the regulatory level, some guidelines are offered on how the contents related to sustainability fit into the Spanish and European legislative framework.

## 2. Climate Change and Sustainability in Educational Legislation: Fit, Novelties and Prospects

As expressed in the introductory section, one of the defining characteristics of the Spanish education system is its instability, which is due, in essence, to the absence of consensus among the country's main political forces about what education should be and in relation to various controversial issues such as private and subsidized education or the subject of Religion (Novella and Cloquell 2021; Fernández-Mellizo 2019).

As already mentioned, unlike what happens in other European countries whose educational legislation remains in force for decades, in barely half a century, as many as nine educational laws have been passed (Figure 1), two of which—the LOECE and the LOCE—never came into force, and others, such as the LOMCE, have had a reduced period of validity. Education thus becomes an ideological battlefield, a circumstance that makes it impossible to meet the objectives contained in the regulations and subjects teachers to a situation of continuous uncertainty in the face of the new curriculum.

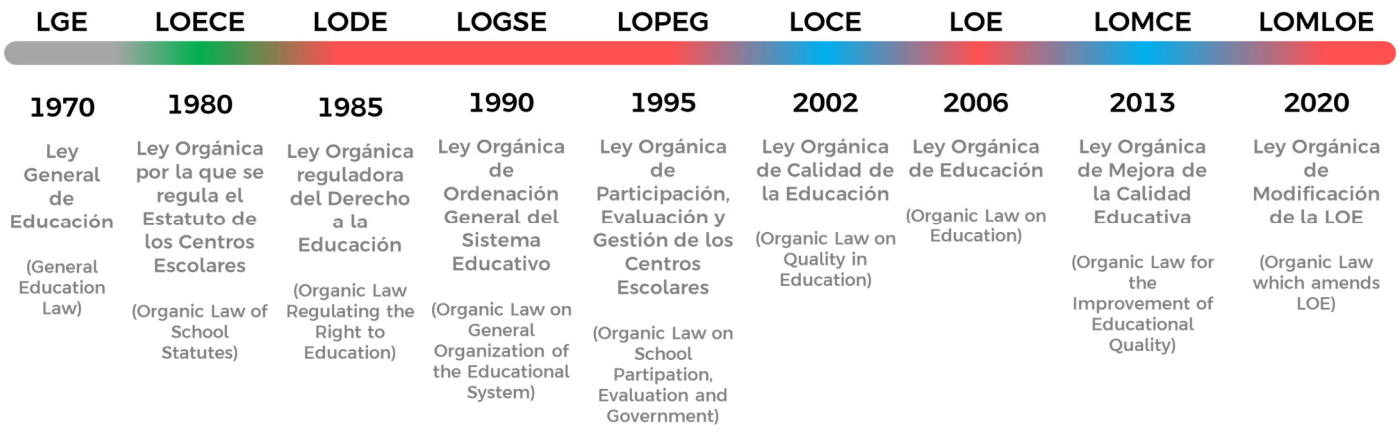


**Figure 1.** Spanish educational laws in the last half century. Own preparation.

Analyzing the latest educational laws passed in this century—LOCE, LOE, LOMCE and LOMLOE—it should be noted that all of them refer, implicitly or explicitly, to the need to raise awareness among secondary and baccalaureate students of the importance of preserving the planet and contributing to their acquiring adequate training in environmental matters.

Thus, the LOCE, approved in 2002, recognized the need for high school students to have the necessary skills to understand and critically analyze "the contribution of science and technology to change living conditions, as well as to strengthen sensitivity and respect for the environment" (BOE No. 307, of December 24 2002).

Notwithstanding the above, the LOE—2006, the law that fully introduced environmental issues in the educational regulations, states that one of the basic purposes of the Spanish educational system consisted in the acquisition of values that favored "respect for living beings and the rights of animals and the environment, in particular the value of forest areas and sustainable development," and indicated, in addition, that a responsible and committed attitude should be fostered in the battle against climate change and unsustainability (BOE No. 106, of May 4 2006).

The LOMCE—2013, on the other hand, the explicit references to climate change and sustainable development disappeared, although, for example, knowledge and prevention

of environmental risks remained among the objectives of vocational training (BOE No. 295, of December 10 2013).

The last educational law, the LOMLOE, was approved in 2020 after a controversial drafting process and a harsh debate and vote in the Congress of Deputies (Torices 2020). In the 2022–2023 academic year, the modifications introduced in the curriculum, the organization, and objectives of the odd courses of primary, secondary, and baccalaureate came into force, while in 2023–2024, those referring to the even courses come into force, including the course with which students are prepared to access university, vocational training, or, directly, the labor market: 2nd year of baccalaureate (Ministry of Education and Vocational Training 2022b).

In any case, the LOMLOE once again places the environmental issue at the center of the educational system. Thus, the promotion of a culture of environmental sustainability and the achievement of sustainable development—referred to on more than twenty occasions in the law—is embedded in the educational regulations with such vigor that they must be addressed in a cross-cutting manner in the different subjects that make up the educational program (BOE No. 340, of December 30 2020).

This is expressed in Royal Decree 217/2022, which establishes the organization and minimum teachings of secondary education, in which teachers are repeatedly invited to encourage students to think critically about the preservation of the environment. It also states that by the end of basic education, students must have analyzed and adopted ideas related to sustainable development. Similarly, it should be noted that the subject of Education in Civic and Ethical Values introduces basic knowledge related to sustainability and environmental ethics, including concepts such as the limits of the planet, climate emergency, circular economy, resilient communities, etc. (BOE No. 76 of March 30 2022). This same philosophy of instruction committed to sustainable development and the environmental challenges facing the Earth is also observed in the Royal Decree establishing the organization and minimum teachings of the baccalaureate (BOE No. 82, of April 6 2022), as well as in the regional decrees that have been approved by the different regional executives to establish with precision the organization and curriculum based on the LOMLOE (BOCM No. 176, of July 26 2022; BOPA No. 169, of September 1 2022; DOE No. 164, of August 25 2022).

## 3. Methods

By virtue of what has been explained up to this point, it becomes obvious that education in sustainability has ceased to be an objective that is only superficially addressed and has turned, at all levels of the educational system, into an imperative within the curricular development. This fact has encouraged pedagogical research, which, in recent years, has tried to provide teachers with tools to face the new teaching challenges related to the environment with guarantees and resources. Among the most outstanding proposals is Murga-Menoyo's (2015), which identifies four competencies for sustainability: (1) critical analysis, including critical thinking and ethical and intellectual commitment; (2) systemic reflection, which contains relational thinking, the feeling of belonging to the community of life, and holistic thinking; (3) collaborative decision-making, developing argumentative and participatory skills and adopting a clear commitment to democracy and universal human rights; and (4) a sense of responsibility towards present and future generations, which refers to ethical and social commitment, anticipatory, synchronic and diachronic thinking, and, finally, universal responsibility and compassion.

In this context, Barak Rosenshine's didactic proposal constitutes an interesting model from which to work on the intended contents and competencies. Since its publication in 2010 (Table 1), it has become one of the most widely used in the educational field (Sherrington 2019; Buzo 2021), having been designed from research based on the way in which the brain acquires and uses new information, the practices carried out by teachers whose students achieve great goals, and, finally, the results of studies that teach learning strategies to students (Rosenshine 2010).

**Table 1.** Rosenshine's Principles of Instruction.

| No | Principle of Instruction | Objective |
|---|---|---|
| 1 | Daily review | To reinforce connections to prior learning by recalling concepts and relationships |
| 2 | Present new information in small steps | To provide new materials progressively, helping students to put the content into practice |
| 3 | Ask questions | To help students consolidate new information and connect it to prior learning |
| 4 | Provide models | To make models and solved examples that can be applied to solve other problems available to students |
| 5 | Guide the student's practice | To consolidate learning by processing and performing trials or practice with the material |
| 6 | Check the student's understanding | To examine the degree of understanding at each step to avoid errors and confusion in learning |
| 7 | Obtain a high success rate | To achieve a success rate of around 80% among the student body |
| 8 | Provide scaffolding for difficult tasks | To allow the student to solve complex tasks through temporary support from the teaching staff |
| 9 | Independent practice | To increase the ability and the autonomy of the student to solve tasks or practices in a fluent way with automated procedures |
| 10 | Weekly and monthly review | To connect ideas through providing materials, conducting discussions, and application activities |

Source: Own preparation from Rosenshine (2010).

The following table reflects the ten principles established by the author, as well as a brief description of their basic objectives:

The learning situation presented below has been designed following these principles. The proposed timing is merely illustrative and should be adapted to the unique characteristics of the students in question. In addition to the activities, the learning objectives, and expected competencies, resources and key concepts to be worked on during the sessions are indicated. It should be noted that multiple online viewers are proposed, whose analysis and interpretation contribute to the acquisition of basic geographic skills.

Regarding the methodologies proposed for the realization of the learning situation, these are the following:

- Collaborative work groups. Group work will be encouraged, promoting the acquisition of skills related to cooperation, coordination, and peer learning.
- Presentation of results and group discussions. The main results of the activities will be presented in groups, and debates will be held to encourage critical thinking.
- Inverted class. In order to achieve that the student works in an autonomous, dynamic, and collaborative way, this technique will be adopted based on the existence of audiovisual resources and other content not specifically explained by the teacher.
- Gamification. The Kahoot tool is integrated in the learning situation as one of the basic resources to favor the assimilation of the contents from a playful perspective.
- Techniques for the construction of concept maps. Students will be invited to elaborate concept maps on the topics addressed.
- Interpretation and elaboration of cartography. Maps analysis is a fundamental geographic technique on which the explanation of phenomena, processes, and relationships can be based.

Regarding the way to evaluate the students' performance in the learning situation, this will depend on the singular characteristics of the group of students with whom we

work and the availability of means and time. However, the instruments with which, in principle, it is planned to evaluate the students are the following:

- Participation in group discussions.
- Observation of behaviors and attitudes during the period of development of the activities.
- Elaboration and, if necessary, exposition of the different works and tasks proposed.
- Elaboration of the final review test or exam.

Notwithstanding the fact that each activity developed presents a specific qualification based on the objectives pursued, the following Table 2 presents a proposal of operational objectives and evidences of achievement that allow to evaluate, as a whole, the effectiveness of the training process and, ultimately, to determine whether the student has acquired the competencies and has satisfied the objectives of the learning situation.

**Table 2.** Operational competences and evidence of achievement.

| Operational Competence (Capacity to...) | Evidence of Achievement (The Student...) | | |
|---|---|---|---|
| | **Level 1 (Approved = Grade C)** | **Level 2 (Remarkable = Grade B)** | **Level 3 (Outstanding = Grade A)** |
| **1. Search, use, and analyze data included in official statistical databases and viewers available online** | 1.1. Is able to describe the available information, identifying general trends by country and region | 1.2. Points out the possible explanatory causes of the observed phenomena or process and explains the reason for the territorial differences | 1.3. Relates the observed phenomena to other processes and points out the importance of human beings on these processes |
| **2. Analysis, interpretation, and interrelation of a variety of cartographic material** | 2.1. Analyzes cartographic material in an appropriate and informed manner, using geographic terminology | 2.2. Is able to relate several maps to reach general conclusions about a specific phenomenon or process | 2.3. Reasons about the underlying variables that can explain the processes represented cartographically |
| **3. Elaboration of simple cartographic compositions** | 3.1. Produces cartography following the established indications and including the basic geographic elements (scale, key, title, etc.) | 3.2. Represents more than one variable on the map, in order to show the relationship between different elements | 3.3. Applies a geoprocessing tool, generating new material from the layers provided |
| **4. Analysis of policy documents related to climate action or sustainability** | 4.1. Is capable of analyzing the content of the regulations related to sustainability, summarizing its most relevant aspects | 4.2. Points out the evolution of Spanish regulations in this area in recent decades, especially with regard to the changes and approval of new legislation | 4.3. Conducts a comparative analysis of the regulatory content related to climate action at the European, national, and regional levels |
| **5. Preparation of complex documents with a formal structure** | 5.1. Reproduces the proposed outline, adheres to the established standards, and completes the different headings in a simple but documented manner | 5.2. Prepares internally coherent documents, maintaining the same line of argument focused on the resolution of the problem | 5.3. Supplements the information required in each task or section with graphics, cartography, examples, audiovisual material, etc. related to the topic |
| **6. Reflection on the interrelation of various concepts (resilience, climate change, sustainable development, adaptation, etc.** | 6.1. Does not limit him or herself to explaining each of the concepts worked on independently, but links common causes and consequences among different phenomena | 6.2. Argues about the bidirectional relationship between sustainable development and climate change | 6.3. Identifies proposals and comprehensive solutions to mitigate the malfunctions of the current socioeconomic system that hinder the achievement of the SDGs |

**Table 2.** *Cont.*

| Operational Competence (Capacity to...) | Evidence of Achievement (The Student...) | | |
|---|---|---|---|
| | **Level 1 (Approved = Grade C)** | **Level 2 (Remarkable = Grade B)** | **Level 3 (Outstanding = Grade A)** |
| **7. Concretization of theoretical and abstract notions (sustainability, resilience, etc.) into specific and quantifiable actions** | 7.1. Provides practical examples on resilience, sustainability, mitigation and adaptation in a complementary way to the theoretical side | 7.2. Proposes specific measures to contribute to sustainable development and mitigation and adaptation in the face of climate change | 7.3. Is capable of establishing simple indicators to evaluate the degree of progress and compliance with the proposed measures |
| **8. Development of scientific reasoning, based on evidence** | 8.1. Backs up their analyses with rigorous and solid sources of information, verifying their initial hypothesis with scientifically proven reality | 8.2. Is able to identify differences and similarities between various databases and sources in relation to the information and data required in the activity | 8.3. Critically integrates in his or her reasoning the strengths and weaknesses of his or her own theses, as well as the opposing arguments, pointing out the issues that may generate controversy |

Source: Own preparation.

## 4. Results

The main result of this work is a learning situation resulting from the combination of Rosenshine's methodology with some innovative approaches that have been published in recent years on the need to work in the classroom on the basis of concrete problems that the students are able to solve on their own or with the help of the teacher.

In order to facilitate its understanding, this section is structured in several subsections: learning objectives, competences to be developed, associated SDGs, basic resources for the student, key concepts, and, finally, the training proposal.

### *4.1. Learning Objectives*

- To recover the learning that students had acquired in previous courses on issues related to climate change in order to broaden them and to be able to relate causes and effects.
- To describe and explain the links between anthropogenic action and climate change, paying special attention to the main activities and countries that generate greenhouse gas emissions.
- To describe, explain, and evaluate the most important risks and disasters of climatic origin, mainly in the Spanish and Canary Islands context.
- To evaluate the impact that climate change could have on our lives, health, and economic and social welfare, as well as on the fauna, flora, and waters of Spain and the Canary Islands.
- To describe, explain, and evaluate the main mitigation and adaptation measures that could be adopted, analyzing, in addition, the special vulnerability of island territories to this problem.
- To know the main methods and sources for obtaining and analyzing meteorological and climatic data, as well as to learn how to interpret graphs and perform simple tasks in Geographic Information Systems—hereinafter referred to as GIS.
- To explain what the SDGs are and describe their connection with the fight against climate change.

### *4.2. Competences to Be Developed*

As already indicated, the students' daily work aims to contribute to the acquisition of the four competences for sustainability pointed out by Murga-Menoyo (2015): critical analysis, systemic reflection, collaborative decision-making, and sense of responsibility towards present and future generations. These are broken down into the following seven operational competences:

1. Search, use, and analysis of data included in official statistical databases and viewers available online.

2. Analysis, interpretation, and interrelation of varied cartographic material.
3. Elaboration of simple cartographic compositions.
4. Analysis of policy documents related to climate action or sustainability.
5. Elaboration of complex documents with a formal structure.
6. Reflection on the interrelation of various concepts—resilience, climate change, sustainable development, adaptation, etc.
7. Concretization of theoretical and abstract notions—sustainability, resilience, etc.—into concrete and quantifiable actions.
8. Development of scientific reasoning, based on evidence.

### 4.3. Associated Sustainable Development Goals (SDGs)

Although Sustainable Development Goal 13 makes explicit reference to climate action, the commitment to and awareness of sustainability and the fight against climate change is inscribed in each and every one of the SDGs (United Nations 2021). Specifically, the contents and activities inserted in the learning situation are directly linked to the goals included in the following Figure 2:


**Figure 2.** SDGs associated with the learning situation. Own preparation

### 4.4. Basic Resources

The following are nine basic resources that students should consult in order to adequately solve the proposed tasks (Table 3):

**Table 3.** Basic resources.

| No. | Resource | Access |
|---|---|---|
| 1 | World Bank Climate Change Knowledge Portal (World Bank Group 2021) | https://climateknowledgeportal.worldbank.org/, accessed on 9 February 2023 |
| 2 | World Bank Climate Change Country Database (World Bank Group 2023) | https://datos.bancomundial.org/tema/cambio-climatico, accessed on 9 February 2023 |
| 3 | Climate projections for the 21st century (AEMET 2011) | https://www.aemet.es/es/serviciosclimaticos/cambio_climat, accessed on 9 February 2023 |
| 4 | Global Climate Monitor (Camarillo-Naranjo et al. 2019) | https://www.globalclimatemonitor.org/, accessed on 9 February 2023 |
| 5 | IPCC interactive atlas (Gutiérrez et al. 2021) | https://interactive-atlas.ipcc.ch/, accessed on 9 February 2023 |
| 6 | Climate Change Scenario Viewer (Adaptecca.es 2021) | https://escenarios.adaptecca.es/, accessed on 9 February 2023 |
| 7 | Sustainable Development Report viewer (Sachs et al. 2022) | https://dashboards.sdgindex.org/map, accessed on 9 February 2023 |
| 8 | Carbon footprint calculator (Cities Footprint Project 2014) | https://huelladeciudades.com/AppHCCali/main.html, accessed on 9 February 2023 |
| 9 | Illustrated dictionary of meteorology (AEMET 2018) | https://meteoglosario.aemet.es/, accessed on 9 February 2023 |

Source: Own preparation.

### 4.5. Key Concepts for Students

The following are the basic concepts with which the students of the 2nd year of baccalaureate will have to become familiar during the development of the learning situation.

#### 4.5.1. Climate

It is the set of atmospheric conditions existing in a given territory during a relatively long period of time. It could also be defined as the average state of the atmosphere in a place on Earth. Conventionally, the minimum period to be able to refer to climate is thirty years; below that figure, one must speak of atmospheric weather, which is the state of the atmosphere at a precise moment or a temporal range of less than three decades (Linés 2010; Torres 2019; WMO 2022).

#### 4.5.2. Climate Change

It is a process of transformation of climatic conditions resulting from the alteration of global atmospheric composition as a consequence, directly or indirectly, of anthropogenic activities, although, at other times, it may have been due to internal factors such as solar cycles or volcanic eruptions, transformations to which it is more convenient to refer to with the expression *climate variability* (United Nations 1992; IPCC 2013).

#### 4.5.3. Sustainable Development Goals

These are seventeen goals adopted by the United Nations in 2015 that seek to move towards improving the well-being of citizens in all countries and human development in all its aspects: education, health, labor, equality, ecology, etc. It is therefore an interrelated framework that seeks to address some of the most pressing issues of our century: inequality, wars, poverty, deteriorating environmental conditions, etc. (United Nations 2015; UNDP 2022).

#### 4.5.4. Climate Emergency or Crisis

This is an expression popularized in recent years that highlights the acceleration of global warming and the other effects of climate change. It is, in short, a term linked to climate change that aims to raise public awareness and draw the attention of institutions to the civilizational threats posed by global change in the making (Amico et al. 2020; Erviti 2020).

#### 4.5.5. Climate Anomaly

It is the deviation recorded in the value of a climate element with respect to its normal values. It is common in scientific analyses of climate change to refer, for example, to thermal or rainfall anomalies—deviations in temperature and precipitation, respectively, caused by climate change (WMO 2017; AEMET 2018).

#### 4.5.6. Sustainability

It is a criterion for action and development based on the fact that the actions of the present should not compromise the right of future generations to enjoy and live healthily on Earth. Therefore, it is a condition in which the use of natural resources and the socioeconomic development of societies does not diminish, deteriorate, or directly suppress the quality of the environment, so that anthropogenic activities can be developed without having a negative impact on the planet (Toro 2007; RAE 2022a).

#### 4.5.7. Vulnerability

The susceptibility of a given population or its assets to be affected by a hazard of any kind. Vulnerability is often assessed taking into account the economic and human resources available to minimize the effects of an event, available infrastructures, political measures related to the issue, etc. (Basque Government n.d.; Biología-Geología.com n.d.; National Association of Safety Directors 2020).

#### 4.5.8. Exposure

The volume of people, assets or systems that may be affected in the case of a disaster of natural origin or of any other kind. Consequently, the level of exposure of an element present in a risk zone will be higher the greater the potential human or economic losses in the event of a disaster (Biología-Geología.com n.d.; Inter-Agency Network for Education in Emergencies 2022).

#### 4.5.9. Prevention

This is a principle consisting of advanced preparation carried out prior to the occurrence of a risk in order to avoid its occurrence or, at least, to reduce its negative impacts on societies or natural and economic resources. Preventive measures are considered the most effective, since they anticipate the occurrence of an accident or disaster by preparing societies or the environment (RAE 2022b; ABC Definition 2022).

#### 4.5.10. Resilience

Resilience is the capacity of living beings—including, of course, human beings—and territories, elements, and systems to adapt to, recover from, and overcome the adverse events in their way and, in addition, to continue their development in spite of the negative circumstances that surround them. In terms of climate, resilience is the capacity of societies and natural environments to cope effectively with the impacts and transformations resulting from climate change (Becoña 2006; FAO 2019).

#### 4.5.11. Mitigation

This is the strategy for combating climate change that seeks to reduce the effects of this phenomenon by reducing or eliminating greenhouse gases present in the atmosphere. For example, actions such as the promotion of renewable energies, the increase in forest mass to enhance $CO_2$ sinks, or the prohibition against driving polluting vehicles in cities are measures framed within mitigation (IPCC 2018; European Environment Agency 2022).

#### 4.5.12. Adaptation

This is the process of adjusting to the current or potential effects of climate change in order to minimize its damages and take advantage of the opportunities it presents. Some examples of adaptation measures are the provision of shaded areas in cities in the face of rising temperatures, the protection of buildings near the coastal edge in the face of rising sea levels, the approval of emergency plans, or the improvement of the sewage system in the face of possible flooding (IPCC 2018; European Environment Agency 2022).

### *4.6. Training Proposal*

With the purpose of facilitating the understanding of the planned activities and sessions, the training proposal presented below has been divided into seven phases: (1) concepts retrieval; (2) construction of basic schemes; (3) management of information sources; (4) introduction to practice; (5) review of learning; (6) autonomous practice; and (7) presentation and evaluation of results.

#### 4.6.1. Phase 1. Concept Retrieval

**Step 1**

- Estimated sessions: 2
- Associated Rosenshine's Principle: (1) daily review

First, in order to check the students' prior learning on some concepts related to the topic, each student will be invited to elaborate two mind maps on their initial knowledge about climate change, on the one hand, and the SDGs, on the other hand. In this sense, students will be given total freedom to shape their outlines as they wish, making them more or less complex depending on their knowledge and skills with digital tools. The use

of the free portal *GoConqr* (GoConqr 2023) is proposed for its simplicity and visual quality. It will be oriented more closely to students with special educational needs, whose outlines will probably be more synthetic, requiring them to prioritize a few essential ideas.

In any case, it is important that the students do not consult any material during the process of elaborating the outline, since the objective is simply to have a record of the degree of prior knowledge on the subject. This material, once elaborated, should be sent to the teacher, who will then be able to know the ideas that their students have about the basic content of the subject before going on to more advanced steps.

At the end of the second session, a questionnaire will be carried out through *Kahoot* or some other platform with a similar purpose, entitled *What do you know about climate change and the SDGs?*, complementary to the mind maps. With these two tools, the first phase, dedicated to concept retrieval, will be satisfied through a simple gamification strategy. These ten questions that could be asked in the initial questionnaire are proposed in Table 4.

**Table 4.** Proposed questions for concept retrieval.

| No. | Question | Answers |
|---|---|---|
| 1 | Which of the following phenomena is not related to climate change? | a. Increased frequency and spread of large wildfires<br>b. Event of seismic movements that sweep away entire cities ✓<br>c. Increasing droughts and decreasing availability of water resources<br>d. Sea level rise |
| 2 | According to most scientists, climate change is a natural phenomenon that happens every few decades | a. True<br>b. False ✓ |
| 3 | Which gas is not considered a greenhouse gas? | a. Carbon dioxide<br>b. Methane<br>c. Hydrofluorocarbons<br>d. Hydrogen ✓ |
| 4 | What is the approximate current concentration of carbon dioxide in the atmosphere? | a. 250 ppm<br>b. 100 ppm<br>c. >400 ppm ✓<br>d. 350 ppm |
| 5 | Which country currently emits the most $CO_2$ into the atmosphere? | a. China ✓<br>b. India<br>c. United States<br>d. Germany |
| 6 | In which year were the SDGs adopted? | a. 2014<br>b. 2015 ✓<br>c. 2017<br>d. 2020 |
| 7 | Which organization has been most closely linked to the SDGs since the initiative's creation? | a. European Union<br>b. United Nations ✓<br>c. OECD<br>d. Council of Europe |
| 8 | How many SDGs are there? | a. Ten<br>b. Fifteen<br>c. Eighteen<br>d. Seventeen ✓ |
| 9 | The SDGs refer only to social issues, such as poverty, resource distribution, or gender equality | a. True<br>b. False ✓ |
| 10 | There are one or more SDGs that specifically address climate change | a. True ✓<br>b. False |

Source: Own preparation.

### Step 2

- Estimated sessions: 3
- Associated Rosenshine's Principle: (6) check the student's understanding

In the third session of the learning situation, the overall results of the completed questionnaire will be analyzed collectively. In addition, the teacher will present a mind map of his own elaboration that will collect the main ideas highlighted by the group of students, even if these were incorrect or inaccurate. Once the results have been objectively presented, the teacher will offer a brief presentation that will clarify the main misconceptions pointed out by the students and will focus on the issues that, in his/her opinion, lend themselves to greater confusion.

The following sessions will begin to work with the following key concepts:

- Climate
- Climate change
- Climate emergency or crisis
- Climate anomaly
- Sustainable Development Goals
- Sustainability

#### 4.6.2. Phase 2. Construction of Basic Outlines

**Step 1**

- Estimated sessions: 3
- Associated Rosenshine's Principle: (2) present new information in small steps

Given the importance of students learning to use rigorous and primary geographic sources, the class will be invited to carry out the activities included in Appendix A, entitled "Workshop: Sources and tools for the study of climate change," which includes practical exercises with six interactive and updated viewers of maximum interest at different scales.

After having installed the free software *QGIS*, and after having been given a brief reminder on how to use the program—which they should have already used in previous courses—a vector layer on climate change will be distributed for students to load in their projects. The link to download the layer is the following: https://drive.google.com/drive/folders/1ww8TdKH2p5Wah_BaFgNEIXQ2NJ1YrdqZ?usp=share_link (accessed on 9 February 2023).

As can be seen in the layer (Table 5), it includes several variables on the subject at the scale of the autonomous communities:

**Table 5.** Fields of the proposed vector layer.

| No | Field | Description |
|---|---|---|
| 1 | POBL_2021 | Population as of January 1, 2021 (INE 2022) |
| 2 | DENSITY | Population density (people per $km^2$) |
| 3 | KM_COAST | Coast kilometers (IGN 2022a) |
| 4 | EMISSIONS | $CO_2$ equivalent emissions by autonomous communities in 2019 in kilotons (MITECO 2019a) |
| 5 | TMIN | Average of minimum temperatures between 1991 and 2020 in °C (World Bank Group 2021) |
| 6 | TMED | Average of average temperatures between 1991 and 2020 in °C (World Bank Group 2021) |
| 7 | TMAX | Average of maximum temperatures between 1991 and 2020 in °C (World Bank Group 2021) |
| 8 | RAIN | Average annual rainfall between 1991 and 2020 in mm (World Bank Group 2021) |
| 9 | ANOMAL_MIN | Estimated minimum temperature anomaly (°C) in 2080–2099 in the *SSP58.5* scenario (World Bank Group 2021) |
| 10 | ANOMAL_MED | Estimated average temperature anomaly (°C) in 2080–2099 in the SSP58.5 scenario (World Bank Group 2021) |
| 11 | ANOMAL_MAX | Estimated maximum temperature anomaly (°C) in 2080–2099 in the SSP58.5 scenario (World Bank Group 2021) |
| 12 | ANOMAL_LLU | Estimated rainfall anomaly (mm) in 2080–2099 in the SSP58.5 scenario (World Bank Group 2021) |
| 13 | LEY_CC | Autonomous communities with their own climate change law |
| 14 | SUP_FOR | Forest area by Autonomous Community in hectares (MITECO 2019b) |
| 15 | DESERT | Approximate proportion of area at significant risk of desertification (Álvarez-Ubría et al. 2007) |
| 16 | HIDRICO | Availability of water resources in thousands of cubic meters in 2018. (INE 2018) |

Source: own preparation.

**Step 2**

- Estimated sessions: 2
- Associated Rosenshine's Principles: (2) present new information in small steps and (3) ask questions

After exploring the data provided in the previous session, students should observe the different variables and discuss collectively the following questions relating the data arranged in the layer with the concepts presented in class:

a. Which do you think are the Spanish autonomous communities most affected by climate change?
b. Do you observe differences between regions? Justify your answer.
c. What is the situation of the Canary Islands in the Spanish context?

Next, they will be invited to calculate their own carbon footprint and compare it, according to the information available on the web, with that of citizens from other countries in the world. It is suggested to use the tool created by the *Cities Footprint* project, whose link is the following: https://huelladeciudades.com/AppHCCali/main.html (Cities Footprint Project 2014).

In the two final sessions of this step, students will have to elaborate a small report, in pairs, where they will answer the following questions:

a. Which are the five autonomous communities that emit the most greenhouse gases into the atmosphere? And those that emit the least?
b. Do all the autonomous communities have legislation or strategies focused on mitigation and adaptation to climate change? When did the Canary Islands pass their climate change law?
c. Which autonomous communities will experience a greater increase in maximum temperatures? What is the situation of the Canary Islands compared to the rest of the country?
d. Do the autonomous communities with the highest risk of desertification coincide with those in which rainfall will decrease the most? Explain your answer.
e. Reflect on the relationship between population density and climate change impacts.

**Step 4**

- Estimated sessions: 2
- Associated Rosenshine's Principles: (3) ask questions and (5) guide the student's practice

Students will be asked to complete the following activity using *QGIS*:

1. Create a folder on your computer or working directory named "Climate_Change_Project" where you will save a *QGIS* project with the name "General_Project." Then, insert the vector layer provided by the teacher.
2. Choose three fields from the layer and represent them in three layouts with all the necessary cartographic elements: title, north arrow, scale, legend, and coordinate system. Students with specific needs will be required only one layout of the variable of their choice.
3. Present the result to the rest of the class, explaining how the product produced can be related to climate change and the SDGs.

Next, a group discussion will be held on the basis of the following questions:

a. Do the Canary Islands share some unique characteristics with the Balearic Islands compared to the mainland?
b. Many experts suggest that the two archipelagos are especially vulnerable to climate change. Why do you think this may be?

#### 4.6.3. Phase 3. Handling of Information Sources

**Step 1**

- Estimated sessions: 1

- Associated Rosenshine's Principles: (4) provide models

Based on the consultation of statistics and viewers available on the Sustainable Development Report portal (Sachs et al. 2022), students should respond in writing to the following questions:

a. What are the indicators included within each SDG? Select them in the left panel and analyze if there are major differences between them.
b. Observe the differences between continents in the degree of achievement of the SDGs.
c. Compare the Spanish situation with the surrounding countries.
d. Selecting the *trends* button. Do you think that substantial progress is being made in achieving the SDGs?

**Step 2**

- Estimated sessions: 2
- Associated Rosenshine's Principles: (7) obtain a high success rate, (8) provide scaffolding for difficult tasks, and (9) independent practice

Based on the explanation and subsequent reflection on the concepts of vulnerability, exposure, prevention, and resilience, students will be provided with the following three maps (Figures 3–5):

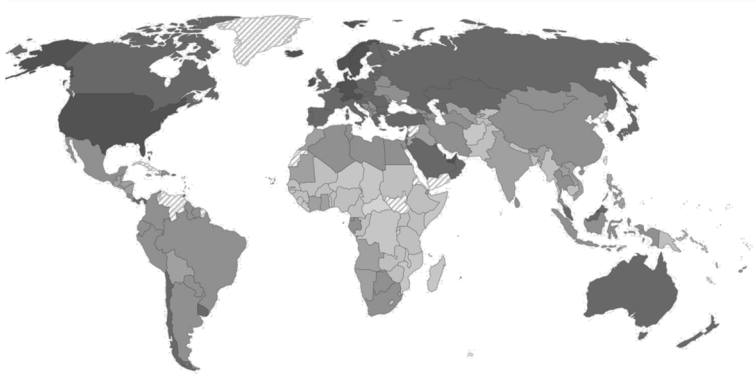

**Figure 3.** GDP per capita. Source: Our World in Data (2020). Countries with darker colors have higher GDP per capita.

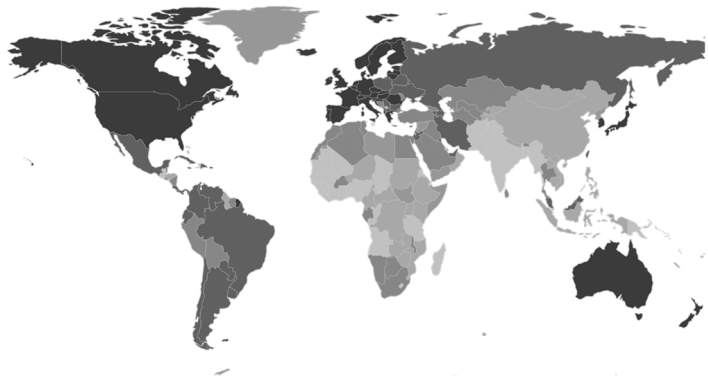

**Figure 4.** Environmental Performance Index—EPI. Source: Fortang (2021). Countries with darker colors have higher potential for climate resilience.

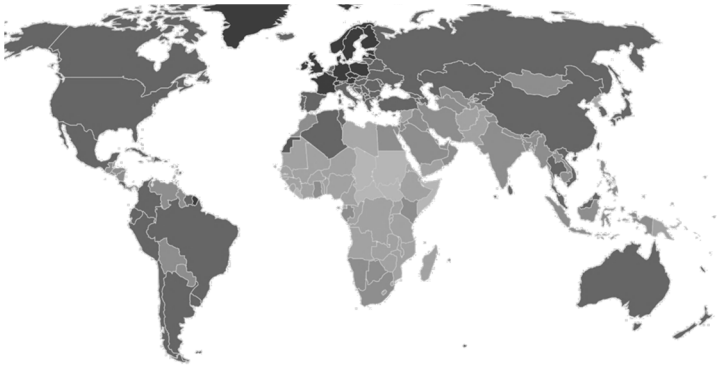

**Figure 5.** Overall score on total progress toward achieving the SDGs. Source: Sachs et al. (2022). Countries with darker colors have a higher degree of achievement of the SDGs.

Next, a group discussion on international inequalities will be initiated around the following questions:

a. Does anything strike you when comparing the three maps?
b. Do you observe any pattern that is repeated in all of them?
c. Do you think that inequality between countries hinders progress towards the 2030 Agenda Goals?
d. From your point of view, what are the main obstacles to the achievement of the SDGs on climate?

The second session of this step will be devoted to the students' autonomous work. Thus, based on the three map sources (Our World in Data 2020; Fortang 2021; Sachs et al. 2022), students will have to choose, in groups of three members, one state from each continent and analyze it according to the aspects considered—wealth, resilience and achievement of the SDGs. To do so, they will be invited to consult any other reliable source or resource they consider useful, paying special attention to the temporal evolution of economic variables in the selected countries.

In the final session, the results achieved will be analyzed; once the situation of multiple countries belonging to various geographical and economic contexts has been presented, the different groups will be invited to write, in a maximum of 500 words and as a conclusion to this step, a reflection on the need to move jointly towards the achievement of the SDGs, seeking information on whether current efforts and cooperation are sufficient to achieve the goals by 2030.

#### 4.6.4. Phase 4. Introduction to Practice

**Step 1**

- Estimated sessions: 2
- Associated Rosenshine's Principles: (2) present new information in small steps, (3) ask questions, and (5) guide the student's practice

In this fourth phase, the student should already have internalized most of the key concepts of the learning situation. Thus, after a brief presentation on the notions of mitigation and adaptation, the following activities will be proposed to the groups formed in the previous phase:

a. After consulting the section referring to environmental risks in the *National Atlas of Spain* (IGN 2022b), as well as the one dedicated to environmental quality and impact (IGN 2022c), what are the main environmental risks in Spain as a whole? And in the Canary Islands?
b. Which of the risks included in the atlas do you think are most related to climate change?
c. How do you think the exposed environmental problems hinder the achievement of the SDGs in Spain and the Canary Islands?

d. What do you think would be the mitigation and adaptation measures that could be adopted in the face of these risks?

The fourth question will be the basis for the individual practice included in phase 6, so it will be emphasized that it is important not to go into the question in depth, but only to sketch some elementary ideas. At the same time, it should be noted that in the fifth phase this group exploration work will be reviewed.

**Step 2**

- Estimated sessions: 2
- Associated Rosenshine's Principles: (2) present new information in small steps, (3) ask questions, and (7) obtain a high success rate

In the second session, the content of Law 6/2022, of December 27, on climate change and energy transition of the Canary Islands (BOC No. 257, of December 31 2022) will be analyzed, encouraging the students' systemic and critical thinking through the following questions:

a. Do you think that the law is aligned with the SDGs?
b. Do you consider that, in general, the measures proposed to address climate change in the islands are sufficient?
c. In the process of drafting the law, an opinion survey was conducted among the Canary Islands population (Consejería de Transición Ecológica 2021—Department of Ecological Transition, Fight against Climate Change and Territorial Planning of the Government of the Canary Islands). Is there anything that strikes you about the public perception?

Finally, based on the work performed by the students and on the main conclusions drawn about the aforementioned law, the results will be discussed in class. In addition, in order for the students to feel prepared for the review that will take place in the fifth phase, a brief overview of the main concepts exposed throughout the learning situation will be carried out.

#### 4.6.5. Phase 5. Learning Review

**Step 1**

- Estimated sessions: 3
- Associated Rosenshine's Principles: (6) check the student's understanding and (10) weekly and monthly review

In order to check the degree of student understanding and to know if the appropriate outlines have been established, the students will repeat the *Kahoot* quiz proposed at the beginning of the subject. Afterwards, they will have to retrieve the mind maps they created in the first weeks of work, so that they can modify, add, eliminate, clarify or, in short, enrich the previously created outlines. Then, by consensus, the students will establish the common elements to be included in all the outlines—for example, causes and consequences of climate change, SDGs related to this phenomenon, incidence in the Canary Islands, etc.

Once the learners have finished modifying their own mind maps, they will have to send them to the teacher, who will now—and not in the first version—evaluate the result. Likewise, the initial and final mind maps of those students who volunteer will be presented, giving way to a brief discussion in which misconceptions and confusions that existed at the beginning of the topic and that now, after the instruction process, have been clarified, can be identified. In addition, the teacher will dedicate a session to analyze with the students the main elements highlighted by the different groups in the analysis delivered in writing in phase 4.

#### 4.6.6. Phase 6. Autonomous Practice

**Step 1**

- Estimated sessions: 4

- Associated Rosenshine's Principle: (9) independent practice

The first session will be devoted to the explanation of the independent practice to be carried out by the students. This will consist of the elaboration of a relatively short written work—approximately seven pages, not including cover page, table of contents, introduction and bibliography—entitled Canary Islands strategy for sustainable development, mitigation and adaptation to climate change. The aim is for students to capture in this document the knowledge they have acquired about the SDGs and climate change, applying it to the Canary Islands scale in the form of a strategy where, in addition to clarifying the basic notions linked to the subject, they propose concrete actions at least three levels: public administrations, companies, and citizens. The title of this learning situation—Climate change and sustainability: from science to our daily life—summarizes what is expected from students with this practice: that they are able, starting from an adequate theoretical basis, to provide simple solutions, to be applied in their daily lives and in the territory where they live, to the environmental problems described by the scientific community. The structure, similar to that of a scientific article, should be as follows:

1. Cover page, table of contents, and introduction, which will include an express reference to the objectives of the strategy at the end.
2. Geographical context of the Canary Islands: physical and human elements.
3. Climate change: causes and consequences. The reality of Spain and the Canary Islands.
4. Mitigation: concept and measures to be applied.
5. Adaptation: concept and measures to be applied.
6. The SDGs as an instrument to achieve resilience: concept, relationship with climate change, and link with the proposed measures.
7. Timing and monitoring: time horizon for implementation of the plan and measures or entities in charge of ensuring compliance.
8. Discussion: examples of strategies approved in other territories, possible limitations of the proposed measures, legal framework of the actions at European and national levels, etc.
9. Conclusions and personal assessment.
10. Bibliography.

The importance of consulting various sources and resources will be emphasized, which should be properly cited in the final bibliography section following the APA style (APA 2021). In order to facilitate the preparation of the work, students will be given a list of accessible resources that they can use to support their arguments, such as the National Plan for Adaptation to Climate Change 2021-2030 (MITECO 2020) or all the regulations, strategies, and climate action plans approved by the Government of the Canary Islands (Canarias por la Transición Ecológica 2022).

Thus, starting from a diagnosis of the situation and the reality of the islands, students will have to put into practice the geographic learning they have acquired throughout their academic career in ESO and baccalaureate, since they will have to make a brief description of the geographic context of the islands, including their physical elements—climate, geomorphology, fauna and flora, etc., and human elements—demography, urban configuration, etc. In addition, they will be invited to work with GIS, having to include, at least, a map of their own elaboration referring to any aspect—location of the islands, climate change, proposed measures, etc. Taking into account that the class will have already worked with the *GoConqr* tool, the inclusion of graphs, diagrams, and other types of figures that visually enrich the final product will be positively valued. Regarding the attention to diversity, for students with specific needs, the GIS task will be optional and, instead of seven pages, the extension will be reduced to five.

The assignment, although individual, will be guided at all times in the classroom by the teacher, who will provide materials, resolve doubts, and help students to focus their own strategy. Taking into account that in the sixth step there will be a blind peer review, it is important that students do not write their name inside the document nor include any

data that could identify them, in order to guarantee the anonymity of the author and an impartial evaluation.

At the end of each session, fifteen minutes will be allocated to check the students' understanding and verify their progress in writing the report, being able to identify their main difficulties in solving the problem.

#### 4.6.7. Phase 7. Presentation and Evaluation of Results

**Step 1**

- Estimated sessions: 1
- Associated Rosenshine's Principle: (10) weekly and monthly review

The students will be invited to elaborate a brief presentation where they will indicate the main lines of the work carried out in the previous step.

Taking into account the level of intellectual maturity of a student who is on the threshold of university, vocational training, or the world of work, once this task has been completed, a blind peer review will be carried out. At random, the teacher will assign each student to correct the work of another student, whose name will not be revealed. A simple grid (Table 6) such as the following will be provided for the correction of the strategies:

**Table 6.** Grid for blind peer review.

| | Element | Not Completed | Partially Completed | Acceptable | Excellent |
|---|---|---|---|---|---|
| 1. | Writing, spelling, and grammatical expressions denote maturity and are appropriate | | | | |
| 2. | Complies with the standards of the work in terms of structure, citation, format, and length | | | | |
| 3. | The definitions provided are clear and come from rigorous sources | | | | |
| 4. | The proposed measures are realistic and sufficient to meet the indicated objectives and are aimed at the three specified levels: administration, business, and citizenship | | | | |
| 5. | The SDGs are well linked to climate change and, in general, are present throughout the strategy | | | | |

Source: own preparation.

Each student must send this grid to the teacher, with a brief global evaluation of the strategy analyzed—about half a page—justifying the evaluation made, which, in any case, will be anonymous in the eyes of other students. Obviously, the implementation of this technique requires a detailed explanation of the criteria that should govern the evaluation, including the need to provide a proactive and improving stance—not disqualifying or destructive—and the importance of being rigorous and fair in the evaluation of their peers.

**Step 2**

- Estimated sessions: 1
- Associated Rosenshine's Principles: (6) check the student's understanding and (10) weekly and monthly review

In the last two sessions of the learning situation, each student, for 5–7 min, will expose his or her presentation on the strategy, having, in addition, to fill in a self-evaluation questionnaire on all the work developed throughout the learning situation. This form should also include questions referring to the degree of satisfaction with the designed activities. Some of the questions could be similar to the following:

a. Do you think that the contents and activities designed have been useful?
b. From 0 to 10, how much have you learned throughout the topic?
c. As a result of the contents raised, has your perception about climate change and sustainability changed?
d. From 0 to 10, how do you rate your personal performance in this topic on climate change and the SDGs?
e. Have you participated in the sessions, contributing ideas, or raising doubts or other questions of interest?
f. Have you handed in all the programmed activities?
g. Have you consulted the resources and bibliographic sources provided in class to solve the problems?
h. Have you modified any daily habits as a result of what has been said about the SDGs and climate change? Do you intend to do so?
i. Taking into account your performance, if you had to give yourself a grade in this topic, what would it be?
j. Which topic was most interesting to you? (Causes of climate change, consequences, climate change in the Canary Islands, international inequalities, the concepts of adaptation, mitigation and resilience, the SDGs, etc.)?

At the end of this activity, the teacher will open a round of discussion on what was raised both in the presentations and in the corrections of the peer evaluation, concluding with a brief mention of the aspects that the teacher considers appropriate to highlight on the topic, the learning process, or the progression of the students.

In order to guarantee the continuity and consolidation of the knowledge worked on, as a suggestion, it is proposed that the next topic to be addressed could be linked to the third group of basic knowledge contemplated in the draft Canarian curriculum, adapted to the LOMLOE, of the subject of geography of the 2nd year of baccalaureate, which refers to "land use planning in the ecosocial approach." In this way, by deepening the issues worked on in this unit, it will be possible to analyze issues such as the sustainability of cities, mobility, urban structure, land occupation in a limited space such as the island, etc., in accordance with the provisions established by the regional authorities of the Canary Islands in the aforementioned draft decree. Likewise, and given the importance of dealing with the SDGs in a cross-cutting manner and common to all subjects, the integrity of the content of the subject should be linked, in one way or another, to the sustainability goals set by international organizations, so that the climate emergency is worked on from multiple perspectives.

## 5. Discussion

The designed learning situation delves into the pedagogical and geographical research initiated after the approval of the SDGs and the consolidation of the concept of education for sustainability. Meeting the goals set by the international community in the field of education can only be a reality if the teaching staff is capable of integrating contents and activities that encourage students to think critically and commit to the preservation of the planet into their daily classroom routine. As Murga-Menoyo (2021) points out, "education [...] as a transforming social force follows its course between possibilism and utopia," so that, in order to avoid repeating the mistakes and failures committed in other previous initiatives—Education For All movement, Millennium Development Goals, etc. (UNESCO 2016)—practical and updated contents are required to help teachers to place themselves more in the realm of possibilism and less in that of utopia.

All of this acquires great importance given the instability of Spanish education and other realities, such as the fact that, for example, geography is included in the same specialty as history, a circumstance that frequently causes geographic content to be relegated to a secondary position, and that a high proportion of teachers stick to a traditional methodology limited to theoretical issues, without integrating innovative activities or those related to current challenges into their daily practice (Peña-Gallardo et al. 2020).

Moreover, in a context of a significant decrease in the number of students enrolled in university studies of geography (Ministry of Universities 2022), it is urgent to adopt new approaches to bring the discipline closer to society and make it more attractive to students, abandoning traditional methods obsessed with the physical and political description of territories to enter a new approach linked to sustainability, work with updated information sources, and the integration of GIS in the classroom.

In this sense, although since the 1990s it has been claimed that technology has revolutionized geography as a discipline and as a school subject (Lemberg and Stoltman 1999), there is still some reluctance in Spain to fully integrate GIS in the classroom, even though there is no lack of didactic proposals (Boix and Olivella 2007; Martínez et al. 2016). In light of this situation, this proposal seeks to contribute to filling this gap in the Spanish educational system.

In the 1980s, it was asserted from the academic world that there was an inadequacy of geography school programs in relation to the real needs of teaching, the dissemination of ideas associated with the "new geographies," the influence of disciplines such as ecology, the new didactic approaches, and the appearance of new materials and resources of interest (García-Pérez 1987). With no intention of adopting a pessimistic perspective, it is axiomatic that some of the deficiencies identified then are still fully valid, especially when the educational world in general is in a situation of continuous disruption and change, and geography must adapt to what UNESCO defines as the end of a historical cycle that initiates the shaping of new educational patterns (International Commission on the Futures of Education 2021).

As professor Monge states, classrooms must be turned into SDG cultivation fields (Monge 2019). To this end, this learning situation seeks to equip students with the key competencies for sustainable development highlighted by UNESCO: systemic and critical thinking, self-awareness, anticipation, normative competence, problem solving, etc. This explains the diversity of activities proposed in the learning situation: analysis of legal documents, work with GIS, reflection on international inequalities, etc.

Therefore, the learning situation presented above seeks to contribute to the adaptation of teaching–learning processes to the international and ethical requirements demanded by modern challenges, in line with initiatives such as the PRADO Guide, a reference document in the pedagogical field that, in a similar way to the present paper, provides examples of activities associated with the SDGs. This guide pursues, in short and in a way that coincides with this proposal, the ultimate goal of helping teaching practices to shape citizens "actively committed to ecosocial sustainability" (Murga-Menoyo and Bautista-Cerro 2019).

It is worth noting that, in addition to the profuse academic reflection on the need to reorient curricula, methodologies, and teaching approaches towards instruction in competencies for sustainability and the adoption of a biocentric educational approach (Araya 2009; Granados and Medir 2021; Corrales 2021), in recent years there has been an increase in educational innovation projects that, from different approaches and disciplines, encourage the implementation of activities and dynamics that involve the entire educational community in a collective project of respect for the environment and environmental awareness (Consejería de Educación, Universidades, Cultura y Deportes del Gobierno de Canarias 2022; Consejería de Desarrollo Educativo y Formación Profesional de la Junta de Andalucía 2022; Consejería de Educación y Cultura del Gobierno de La Rioja 2022).

The proposed learning situation is based on Rosenshine's method, whose instructional principles are increasingly applied to geographical contents (Buzo 2021; De Lázaro and Puertas 2022). Notwithstanding this, it should be noted that the design and timing of the

proposed activities are only intended as a guide that can be freely used by teachers of any subject and educational level in a flexible manner, selecting those aspects considered useful according to the needs of the group, the previous learning and concerns of the students, the legislation of each autonomous community, and the objectives included in the didactic programming documents. Although there are other methodologies that can be used for the configuration of learning situations, Rosenshine offers a way of working based on simple steps that can be applied to different contexts and educational profiles, a circumstance that makes this didactic proposal totally or partially replicable in various contexts. At the same time, it is an approach that facilitates attention to diversity.

Among the limitations of the didactic proposal, it can be pointed out that it may pose overly ambitious objectives considering the reality that the secondary and baccalaureate teacher has to assume: students with specific educational needs, generalized low academic level, lack of interest on the part of large sectors of the student body, scarcity of time and means to develop the pedagogical activity in an adequate manner, etc. However, as mentioned above, the resources and tasks mentioned can—and should—be adapted to the particular characteristics of the students and subject where the learning situation is to be implemented.

Among future lines of research, it would be worth mentioning the interest in developing work that responds to the necessary attention to diversity in geography classrooms, as well as proposals to adapt the instruction of geographic content to the teaching of adults and to integrate geography in the concept, increasingly in fashion, of lifelong learning (Belando-Montoro 2017).

## 6. Conclusions

The teaching of geography is acquiring an enormous importance nowadays. Contents such as climate change, sustainable development, resilience, and adaptation have been included in educational regulations as transversal elements that should permeate the daily practice of all subjects. Therefore, it is essential to provide teachers of this and other specialties with resources and didactic proposals that facilitate the teaching–learning process and increase the environmental awareness of students who, in turn, demand knowledge on these issues in order to position themselves in a society that is increasingly concerned and informed about the ecological issue. In short, education, as a tool for transformation and social change, is today a field of unquestionable interest for effectively addressing contemporary challenges that cannot be tackled with obsolete methodologies.

To meet these objectives, specific activities are required that, like the learning situation proposed in this paper, place students in a position of active and autonomous work that allows them to acquire proactive competencies and skills to contribute, from their daily lives, to the objectives set by the authorities in terms of sustainability. At the same time, this should be performed without ignoring the importance of instructing students in other elementary geographic knowledge that all students should have at the end of their time in the educational system. Likewise, working with GIS, the analysis of regulatory documents, and the handling of official databases are nowadays basic and priority elements that must be integrated, without delay, in the classrooms of geography, a discipline that must respond, as it has already done in other complex historical moments, to the main social challenges.

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## Appendix A. Workshop: Sources and Tools for the Study of Climate Change

The following is a list of viewers and interactive resources that students should use to reflect on various questions:

1. **IPCC Interactive Atlas**

Access to the resource: https://interactive-atlas.ipcc.ch/, accessed on 9 February 2023.

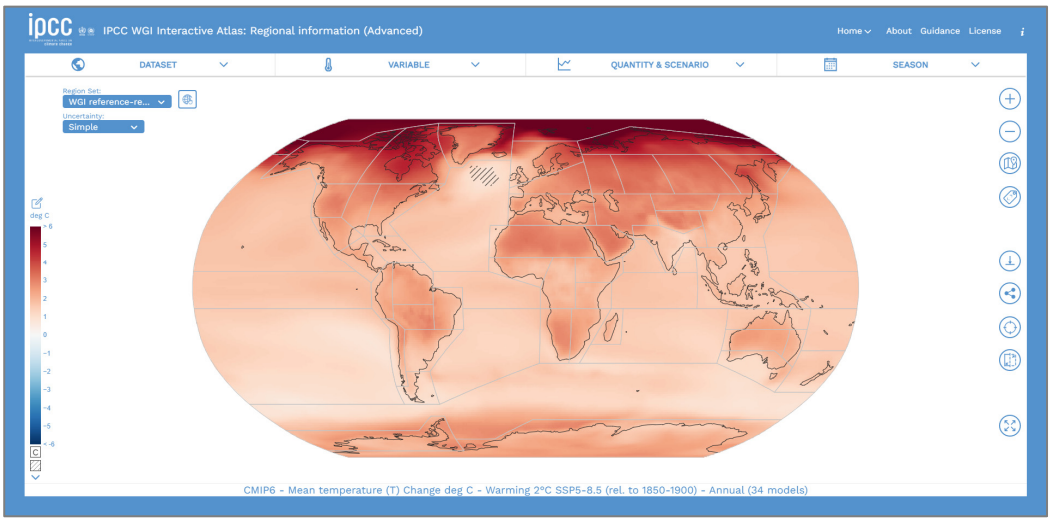


**Figure A1.** Overview of the resource. Source: Gutiérrez et al. (2021).

Questions for reflection and reinforcement of concepts:

a. According to the various projections, which hemisphere will experience the greatest warming by the end of the century?
b. At what times of the year will the greatest thermal increase be experienced?
c. Observe the differences between ocean warming according to scenarios.
d. Where will sea levels rise the most?
e. Observe the changes in sea pH according to scenarios (variable: ph at surface).
f. Observe the retreat of ice cover by the end of the century according to the worst-case scenario (variable: sea ice concentration).

2. **Climate Change Scenario Viewer (Adaptecca.es)**

Access to the resource: https://escenarios.adaptecca.es/, accessed on 9 February 2023.
Questions for reflection and reinforcement of concepts:

a. What is expected to increase more in the Iberian Peninsula, the minimum or maximum temperature (select distant future)? Link it to the evolution of the thermal amplitude variable in degrees.
b. What is the approximate maximum duration of heat waves in the Community of Madrid and the Basque Country according to historical records? And according to the RCP 8.5 scenario?
c. At the end of the century (select distant future), which autonomous communities will see the greatest decrease in precipitation?
d. Regarding the maximum 24 h precipitation variable (select relative anomaly), what do the results suggest to you? What about potential evapotranspiration?

1. **Sea Level Projections Tools (NASA)**

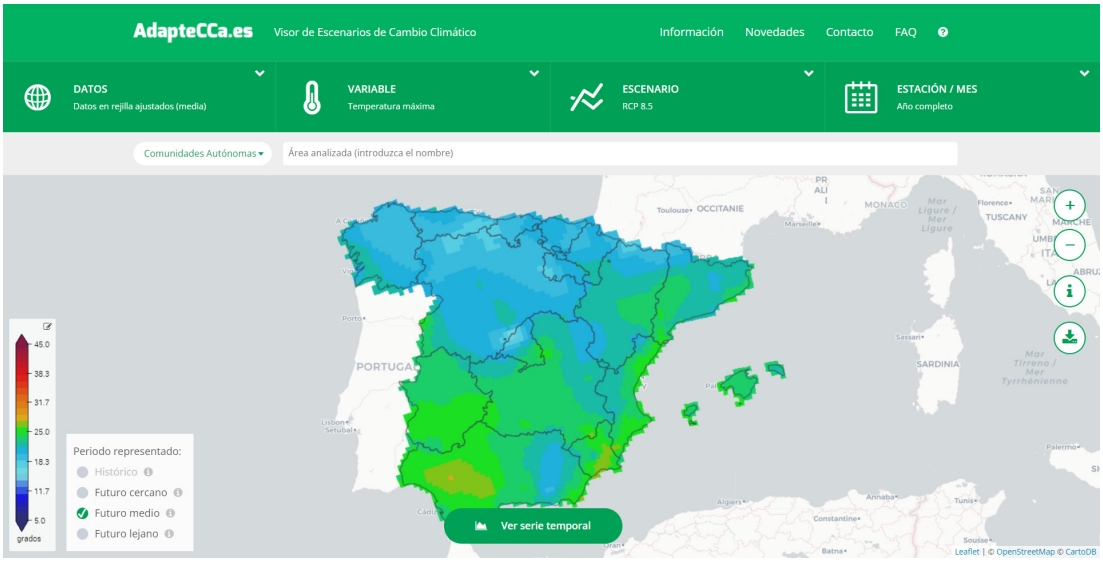


**Figure A2.** Overview of the resource. Source: Adaptecca.es (2021).

Access to the resource: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool, accessed on 9 February 2023.

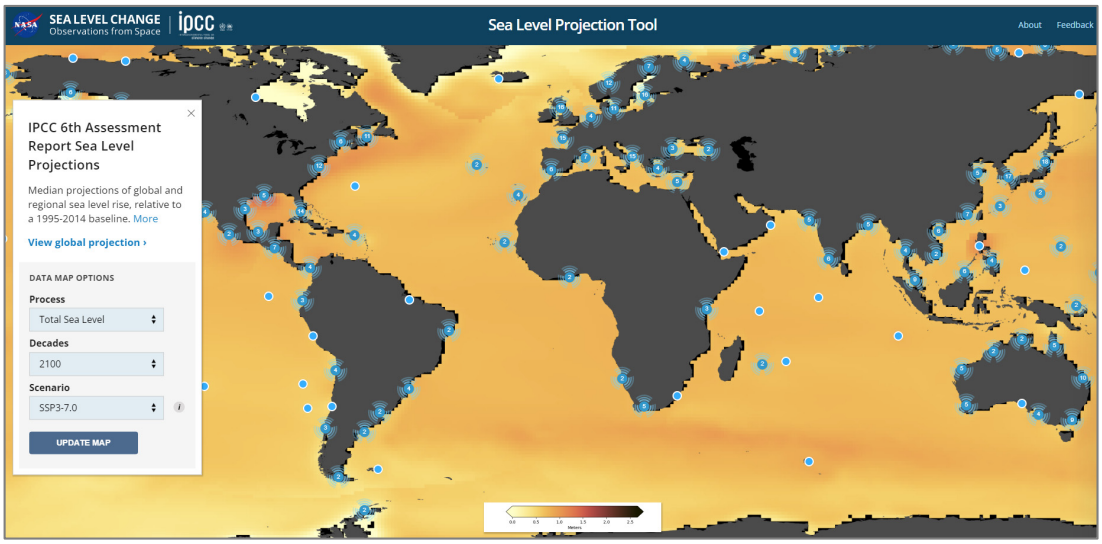


**Figure A3.** Overview of the resource. Source: NASA (2021).

Questions for reflection and reinforcement of concepts:

a. According to the worst-case scenario, SSP5-8.5, by how many centimeters will sea level rise by the end of the century (2100) in Tenerife, and in other parts of the Canary Islands, and in Barcelona?
b. In which areas of the world will sea level rise the most? Give an example.

**2. Risk Zone Map (CLIMATE CENTRAL)**

Access to the resource: https://ss2.climatecentral.org, accessed on 9 February 2023.

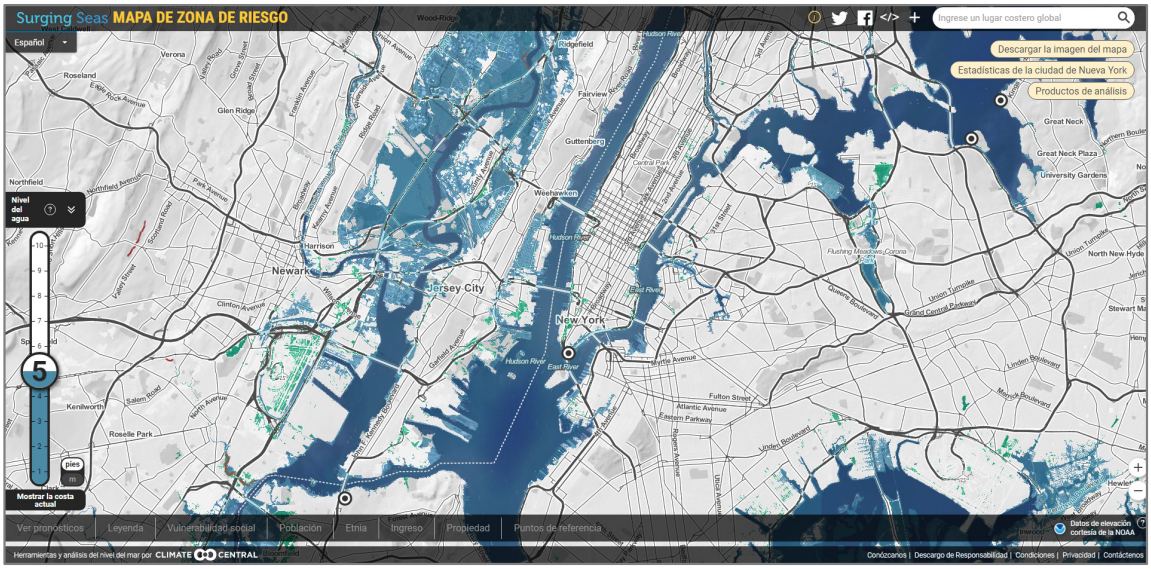


**Figure A4.** Overview of the resource. Source: Climate Central (2023).

Questions for reflection and reinforcement of concepts:

a. Observe what would happen in the Canary Islands with an increase of 1, 2 and 5 m in sea level and compare it with the Spanish peninsular coast and, in general, the European coastline. Is there anything that draws your attention?

**3. Coastal Erosion Viewer (GRAFCAN)**

Access to the resource: https://grafcan1.maps.arcgis.com/apps/webappviewer/index.html?id=a1bc45dd09994ac1979479fcff4db989, accessed on 9 February 2023.

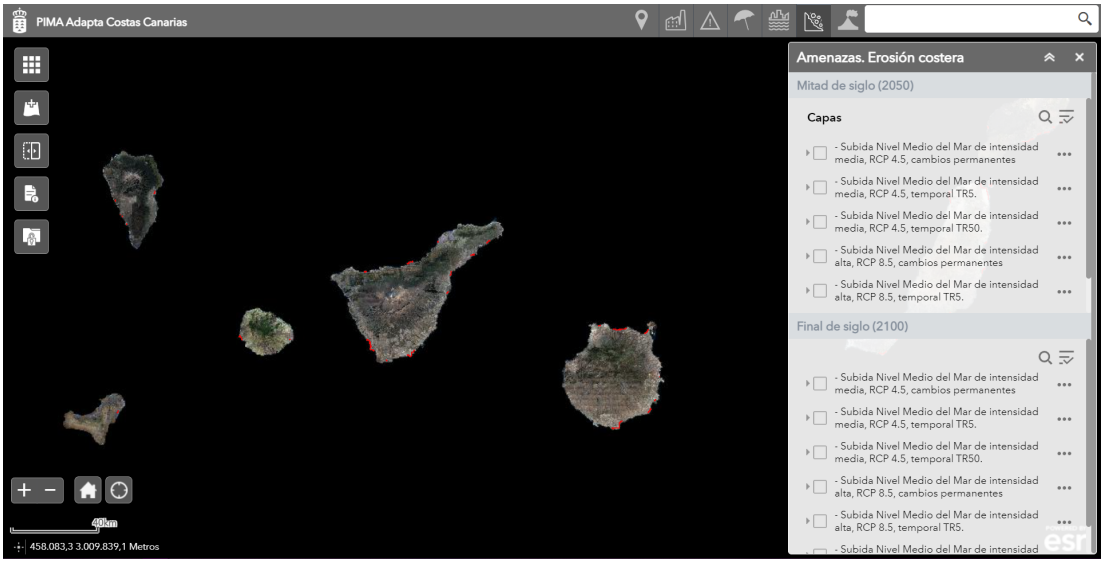


**Figure A5.** Overview of the resource. Source: GRAFCAN (2022a).

Questions for reflection and reinforcement of concepts:

a. In the Canary Islands, which coastal locations would be most affected by sea level rise? Name at least one place on each island.

b. Reflect on the impact that what is represented in the viewer could have on tourism in the archipelago.

**4. Natural Hazards Viewer (GRAFCAN)**

Access to the resource: https://visor.grafcan.es/visorweb/, accessed on 9 February 2023.

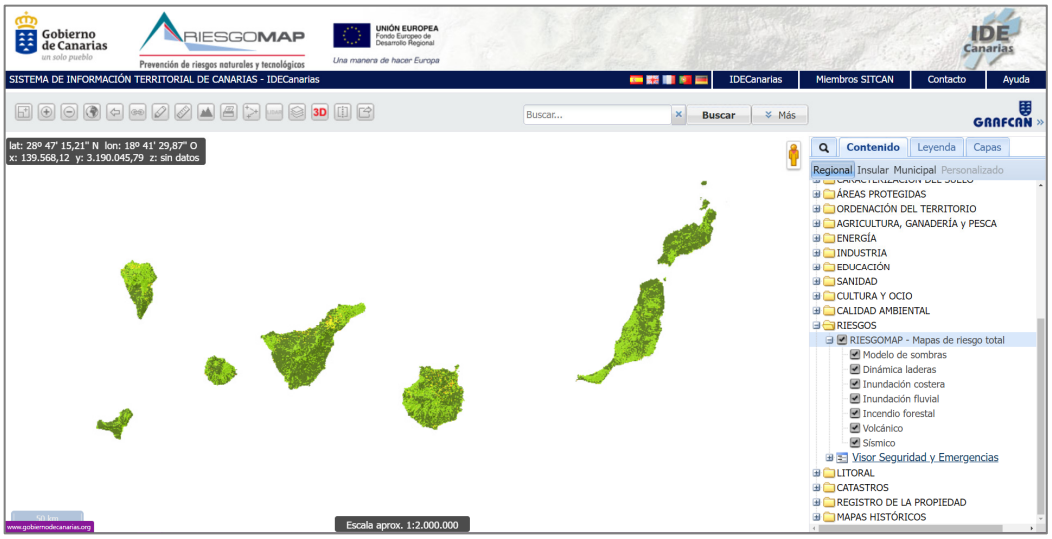


**Figure A6.** Overview of the resource. Source: GRAFCAN (2022b).

Questions for reflection and reinforcement of concepts:

a. Selecting the risk layer included in the left side menu, click on your area of residence, or any space of interest, and analyze the risk situation.

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